SSWR 3.03.b Assessing challenges to sustainable water resource management from underground injection practices (Task Lead, Rick Wilkin, ORD-NRMRL-Ada)

Product Title: Groundwater modeling in support of aquifer exemption determinations

Product Contact: Stephen Kraemer, ORD-NERL-Athens (kraemer.stephen@epa.gov)

Product Delivery Date: Sept 30, 2019

Product Description:

In most situations it is straightforward to make the determination that the area of potential impact of a proposed wastewater injection does not and will not impact an existing or future water supply or irrigation well.   Yet in some situations, the determination is not as clear, and computer modeling and mapping may play a role.   The geologic separation of the exempted zone from an underground source of drinking water may be vertical with many low permeability geologic layers providing redundant barriers.   In cases where the separation distance is horizontal, geologic separation may not be insured by aquitards but by hydrologic separation defined by flow pathways and residence times influenced by pumping/injection.   And there may be situations where combinations of vertical and horizontal isolations may be present.   In all cases, the presence of natural fracture zones (e.g. faults) or artificial penetrations (e.g. abandoned wells) may compromise the separations. In the situations of challenging determinations, a site characterization approach integrating field data collection and assessment and numerical simulation of system performance may be appropriate.

For example, the O&G applicant for a UIC Class II aquifer exemption permit might use numerical simulations to delineate the capture zone of any nearby pumping wells associated with the withdrawal volume over the expected lifetime of the wells. The applicant may use computational simulations to delineate the fate and transport of the injectate over the expected injection period.   The superposition of the drinking water well capture zone, and its associated uncertainty, and the injection well area of impact, and its associated uncertainty, would be part of the supporting package evaluated by the state and EPA.

The goal of this research is to further the development of simplified semi-analytical solution techniques as a complement to complex numerical solution techniques as part of a step-wise modeling approach for aquifer exemption determinations. The California oil and gas wastewater injection wells and the aquifer exemption determinations is proposed to be used as a dataset to test the utility of the modeling approach.   Given the sensitivity of the O&G data, it might be better to start with an analogy to the injection of brine water into fresh water, and develop the technology while modeling the injection of fresh water to create barrier to intruding sea water along the coast of the Los Angeles basin.

Product's Contribution to Output:

Product's Timeline (with milestones):

Sept 30, 2016	Approved QAPP and extramural support
Sept 30, 2017	Development of semi-analytical solvers
Sept 30, 2018	Testing of semi-analytical solvers CA datasets
Sept 30, 2019	Final Report

Products intended user/customer/audience: EPA Regional Administrator and staff

Is this a key product? No

Does this product contribute to products under another Task?

SSWR 3.01.d modeling watershed sustainability

Extramural resources

Financial vehicle	FY16	FY17	FY18	FY19
Contract – semi-analytical software development	$50K	$50K	$50 K	$50 K
Potential Interagency Agreement (e.g., LBNL)	$75K	$75K	$75 K	$75 K

Intramural resources

Staff Member	L/C	Division	Expertise	Contribution to Project or Task	FY16 FTE	FY17 FTE	FY18 FTE	FY19 FTE
Kraemer	NERL	ERD	groundwater hydrologist	overall design and implementation, groundwater modeling	0.5	0.5	0.5	0.5

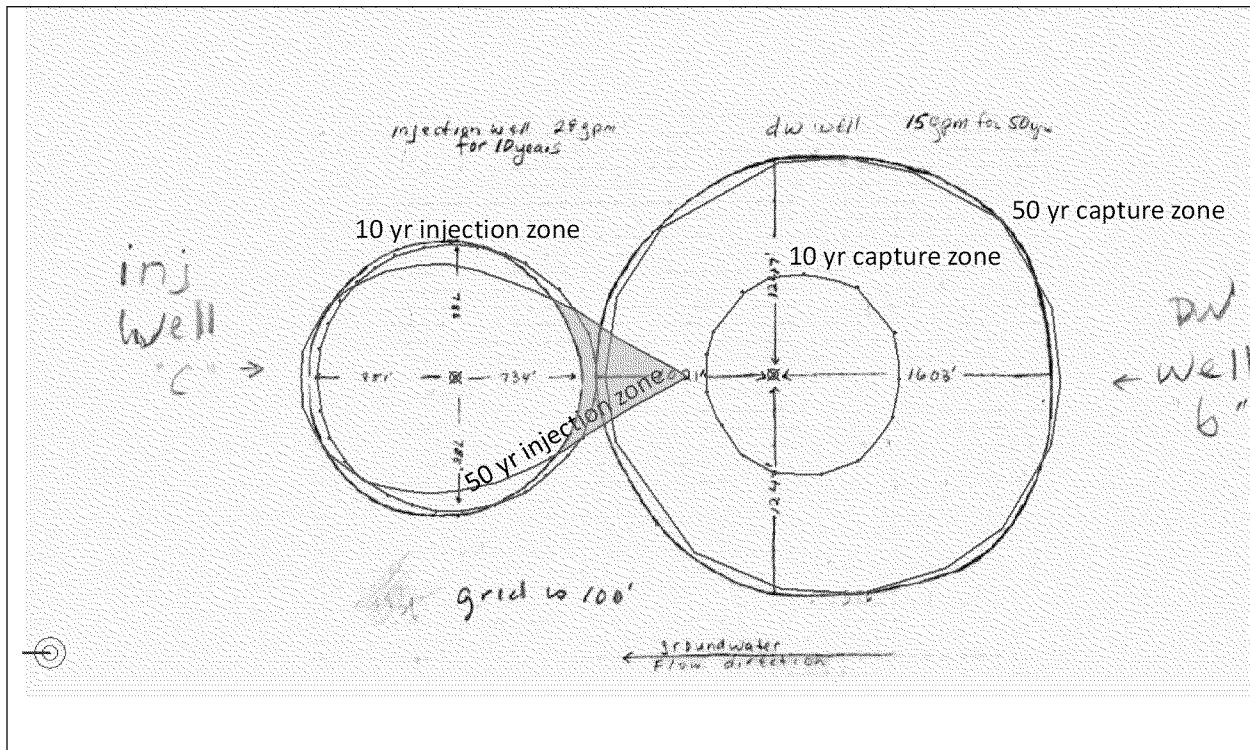| Equipment and Supplies	FY16	FY17	FY18	FY19
computer - equipment and supplies	$20K	$20K	$20 K	$20 K

Figure 1. Example of a capture zone for a drinking water well over years 0-50 of continuous pumping, and an area of influence of an injection well during years 0-10. The highlighted area shows migration of injectate after the injection well is shut down, years 10-50. Note the regional uniform flow direction from right to left. The semi-analytical GFLOW model represented the two steady state periods (yrs 0-10 both injection and pumping, and yrs 10-50 pumping only) and streamline tracing to estimate envelopes. (This is a rough sketch … working with Marilyn Ginsberg OGWDW).

Bibliography

CAPTURE ZONE DELINEATION

Kraemer, S.R, H.M. Haitjema, V.M. Kelson, 2007.   Working with WhAEM2000: capture zone delineation for a city wellfield in a valley-fill glacial outwash aquifer supporting wellhead protection, US Environmental Protection Agency Report EPA/600/R-XX/XXX (update in progress)

DEFINITION OF CRITICAL PRESSURE
Jens T. Birkholzer, Jean Philippe Nicot, Curtis Oldenburg, Quanlin Zhou, Stephen Kraemer, and Karl Bandilla, 2011. Brine flow up a well caused by pressure perturbation from geologic carbon sequestration: static and dynamic evaluations, International Journal of Greenhouse Gas Control, 5:850-861, doi:10.1016/j.ijggc.2011.01.003.

CAMELOT SOLVER (single layer, with or without leakage, camelotpy.googlecode.com)
Bandilla, Karl W., Stephen R. Kraemer, and Jens T. Birkholzer, 2012. Using semi-analytic solutions to approximate the area of potential impact for carbon dioxide injection, International Journal of Greenhouse Gas Control, 8:196-204, doi:10.1016/j.ijggc.2012.009.

TTim SOLVER (multilayer with diffuse and focused leakage, ttim.googlecode.com)
Bakker, Mark, 2013.   Semi-analytic modeling of transient multi-layer flow with TTim, Hydrogeology Journal, 21:935-943, doi 10.1007/s10040-013-0975-2.

ASLMA SOLVER (multiple layer, with diffuse and focused leakage)

Cihan, Abdullah, Quanlin Zhou, and Jens T. Birkholzer, 2011. Analytical solutions for pressure perturbation and fluid leakage through aquitards and wells in multilayered-aquifer systems, Water Resources Research, doi:10.1029/2011WR010721.

Cihan, Abdullah, Quanlin Zhou, Jens T. Birkholzer, Stephen R. Kraemer, 2013. Flow in anisotropic multilayered aquifer systems with leaky wells and aquitards, in preparation.

GeoSequestration web interface
(currently runs on RTI server; exploring the possibilities of porting over to the ERD-Athens server).

BAEM desktop interface
(built using the .NET framework and the MapWindow GIS, includes plug-ins for CAMELOT with FRAMES-based Monte Carlo uncertainty, TTIm, and ASLMA, all currently in beta test)